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Design of an electric power and lighting plant at Saybrook, Illinois

Electrical Engineering

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DESIGN OF AN ELECTRIC POWER AND LIGHTING PLANT AT SAYBROOK, ILLINOIS

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BY

HARRY DAVID EASTERBROOK

AND

THORBJORN KJUS ENGER

THESIS

FOR

DEGREE OF BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE 1910

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HARRY DAVID EASTERBROOK and THORBJORN KJUS ENGER

ENTITLED DESIGN OF AN ELECTRIC POWER AND LIGHTING PLANT AT SAYBROOK, ILLINOIS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Electrical Engineering

Edw. H. Waldo.
Instructor in Charge

APPROVED: Ernst J. Berg

HEAD OF DEPARTMENT OF ELECTRICAL ENGINEERING

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DESIGN OF A LIGHT AND POWER PLANT FOR SAYBROOK ILLINOIS.

Saybrook, Illinois is a village of about one thousand inhabitants, situated twenty-six miles south east of Bloomington upon the Lake Erie and Western railroad. The occupations of the inhabitants are those which are found in nearly all small places located in farming communities in central Illinois. There are three classes, merchants, retired farmers and laborers. The fact that two banks are located there indicates that the people are prosperous, and the concrete walks and other municipal improvements show that they take a great interest in the affairs of the place. There are three well built churches and an excellent school building in the village.

There is no probability that the village will decrease in size, or that land values will decrease as the years go by; in fact, as the country becomes more thickly settled, the price of real estate continually advances. Its growth in the past has been slow, but steady without any booms, and it can be safely said that its rate of growth in the future will be much the same as in the past. As a manufacturing site it has no advantages over any other place in this region, so no development need be looked forward to in that direction. There is however a steady growth of the gravel output of the place, which is a very important point to be looked to in designing of a power plant. This industry has recently been started on a large scale and promises to be a governing factor in the design of a power plant.

There is a good supply of water which is found from twenty to

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forty feet below the surface. Coal is easily obtained at a low price, as it has to be shipped but twenty-five miles. The coal is of a fair quality and contains about twelve thouaand B. T. U. per pound. Land can be bought at an average price, and the railroad has switches along the track beside which a power plant can be situated so that the coal will not have to be hauled or handled twice.

In designing a power plant for this place several important things must be considered, whether it will prove a paying proposition or not, the kind of a plant, the kind of service, the growth of the plant after being erected. A plant can be either one of the following:- hydroelectric, steam, producer gas or gasoline plant. After careful consideration, and since coal is very cheap, no water power is available, a producer gas plant has a high first cost and gasoline is only suitable for small plants, it is thought best to install a steam plant.

As a steam plant has been decided upon, it remains to be decided whether it shall be direct current or alternating current.

This can only be decided by actually figuring the cost of the transmission line and other apparatus. This depends almost entirely upon the cost of the transmission line, as the cost of the alternating current machinery will be about the same as that of the direct current machinery. If the cost of copper for the direct current line is higher than that of the A. C. line plus the cost of the A. C. transformers, it will be advisable to use the A.C. transmission. In order to decide this point the following assumptions and calculations were made:-

A plot of the town having been obtained and a canvass of the houses and stores made, it was found that 2400 lamps would be subscribed for. Since in good practice, power for one fourth of the

total numbers of lamps must be generated, power must be generated for 600 lamps. Assuming that the general class of people will use 16 cancle power carbon lamps, this would be 600 x 55 or 33000 watts of power to be generated. The town will pay $80 per year per lamp for 16 500 watt arcs. This will be 16 X 500 or 8 K. W. of power. Then the total light load will be 41 K. W. assuming 95% effeciency in transmission the total load to be generated will be 43 K. W. Assume 4% drop, which is a good value for lighting service, and that copper costs 15 cents per pound, direct current transmission to be at 220 volts 3 wire, A. C. transmission to be at 2300 volts 2 wire. The pole line having been designed, the arc lamps placed and the line divided in to sections for convenience the following calculations are made:- 43 K. W. at 220 volts will give 200 amperes will be divided among the several branches as follows:-

Section	Distance in ft.	Amp. carried	Size	Drop in volts	Wt. per 1000 lb	Cost at 15 cts. per lb.
a	310	200	1125000 cir.mil	2.2	3300	$ 600
b	300	175				
c	520	76	450000	1.72	1360	213
d	300	63	"	.95	1360	122
e	825	33	400000	1.9	1200	396
f	1050	21	350000	1.7	1050	330
g	1125	15	3/0	2.1	507	176
h	600	93	450000	4	1360	368
i	300	4	"			
j	750	15	1/0	2.25	319	72
k	750	28	4/0	2.1	640	144
l	1050	25	250000	2.2	760	240
				Total cost of wire		$2,561

With A. C. transmission at 2300 volts and 43 K. W. the current would be 19 amperes. Now for convenience assume that this 19 amperes would go over the longest branch without any flowing off into other branches. In reality it does not do this, but the size of wire can be approximately calculated by this method. 4% drop at 2300 volts would be 93 volts drop. The longest branch is 3300 ft. long, and 19 amperes with 92 volts drop would take no 8 B. & S. wire. wt. of this wire per 1000 ft. is 50 lbs. Cost of wire for total line of 7880 ft. at 15 cts. per lb. would be $120. This gives 2,561- 120 which is $2441 for buying transformers. A rough estimate on the cost of transformers to be used is $1400. This gives a saving of $1041 in favor of the A. C. transmission line. From these calculations it is seen that the A. C. transmission is the most economical plan.

Another important point to be settled is whether the plant is to be run condensing or non-condensing. This question depends upon the saving made in operating expenses of the condensing as compared to the extra first cost of the condensing apparatus. A less important consideration is, that the operators will in all probability be low salaried men, and they will be better qualified to operate the plant, if the machinery is not too complicated. The fact that the plant should have as low first cost as possible, consistant with good service, should also be kept in mind. If the condensing system is used, it would be wise to use a turbine generator, but if the condensing is not used it would be better to use an engine driven generator. Condensing water can be obtained by piping to a river 600 feet away or by pumping from a well at the plant. In either case plenty of water can be secured for condensing purposes. The saving if there is any in a condensing plant is in the amount of coal saved.

From the following calculations it can be seen that the non-condensing plant is the better proposition.

Non Condensing:-

125 H. P. reciprocating engine	$1650
75 K. W. generator	1500
Total cost	$3150

Condensing:-

Turbo Generator 75 K. W.	$4000
Condensing apparatus	525
Extra piping	100
Total cost	$4,625

75 K. W. apparatus is figured on, as a motor load is to be considered in the design of the plant. This gives $1475 in favor of a non-condensing plant. Saving in coal by running condensing is as follows:- The saving is 33.5 B. T. U. per lb. of steam used. 2140 lbs. steam per hr. is 71000 B. T. U. per hr. when running at full load. Assume the plant to run at full load 15 hrs. per day and 360 days per year. Then the total saving in B. T. U. per year is 382,000,000. As one lb. coal has 12000 B. T. U., the saving in coal per year is 25000 lbs. At $1.25 per ton the saving is $15.60 per year. At 14% Ins ., Dep., and Ins. on the extra coat of the condensing apparatus, is 14% of $1475 which is $206. It can be plainly seen that the condensing plant in this case is not a good plan.

Assume now a reciprocating engine to run condensing. The coat of the apparatus complete would be $3775 or an extra cost over the non-condensing plant of $625. 14% of 625 is $82.50. This is still more than the saving made in the coal cost of the condensing plant. Therefore it is decided to run non-condensing.

The motor load mentioned above is 2, 50 H. P. Induction

moters which will make up the day load. This load will be generated for 10 hrs. per day. These two motors are for running sand pumps and will not be run at full load all the time, but their full load power must be generated in case they do run at full capacity. These motors will be shut down for one hour at noon which gives ample time to oil and keep the machinery at the plant in good condition. This day load will give the largest income and should be carefully planned for. Since the starting of single phase induction motors is difficult, the three phase system must be used in the day time. But at night for the lighting load, the single phase system is better.

The fact that the day load is 75 K. W. and the night load is only 43 K. W., brings up the question whether there shall be one large unit large enough to carry all the day, or one large enough to carry all the night load and a second unit to make up for the remainder of the day load. This depends upon several factors. First the extra firat cost of the two units as compared to the one unit. Second the higher effeciency of running two units at full capacity as compared to running one unit at half capacity part of the time. Third the assurance against a total shut down of both units, and the quarantee to the people of a continuous lighting service. In the last case the people could afford to pay a higher rate for their power if they were sure of continuous service. This is a big point in favor of the two units. Then again if one unit was out of commission, some of the power could be furnished to the motors by the remaining unit. In the second consideration, although the saving of effeciency is not so great, it is a point in favor of two unit system. The first sonsideration is the greatest drawback to the two units, and in order to decide, the following calculations and assumptions are made.

Case 1. one unit system.

Direct connected.

75 K. W. generator		$1500
Exciter		125
125 H. P. engine		1290
Setting		100
140 H. P. boiler		945
Boiler setting		500
	Total	$4460

Belted generators

75 K. W. generator		$1000
Exciter		110
140 H. P. boiler		945
Boiler setting		500
125 H. P. engine		1290
	Total	$3845

Case 2 two unit system

Directconnected

50 K. W. generator		$1260
25 K. W. generator		950
80 H. P. engine		1000
40 H. P. engine		750
Engine settings		196
Exciter for 50 K. W. machine		110
" " 25 " "		80
2 65 H. P. boilers		1000
2 settings		740
	Total	$6086

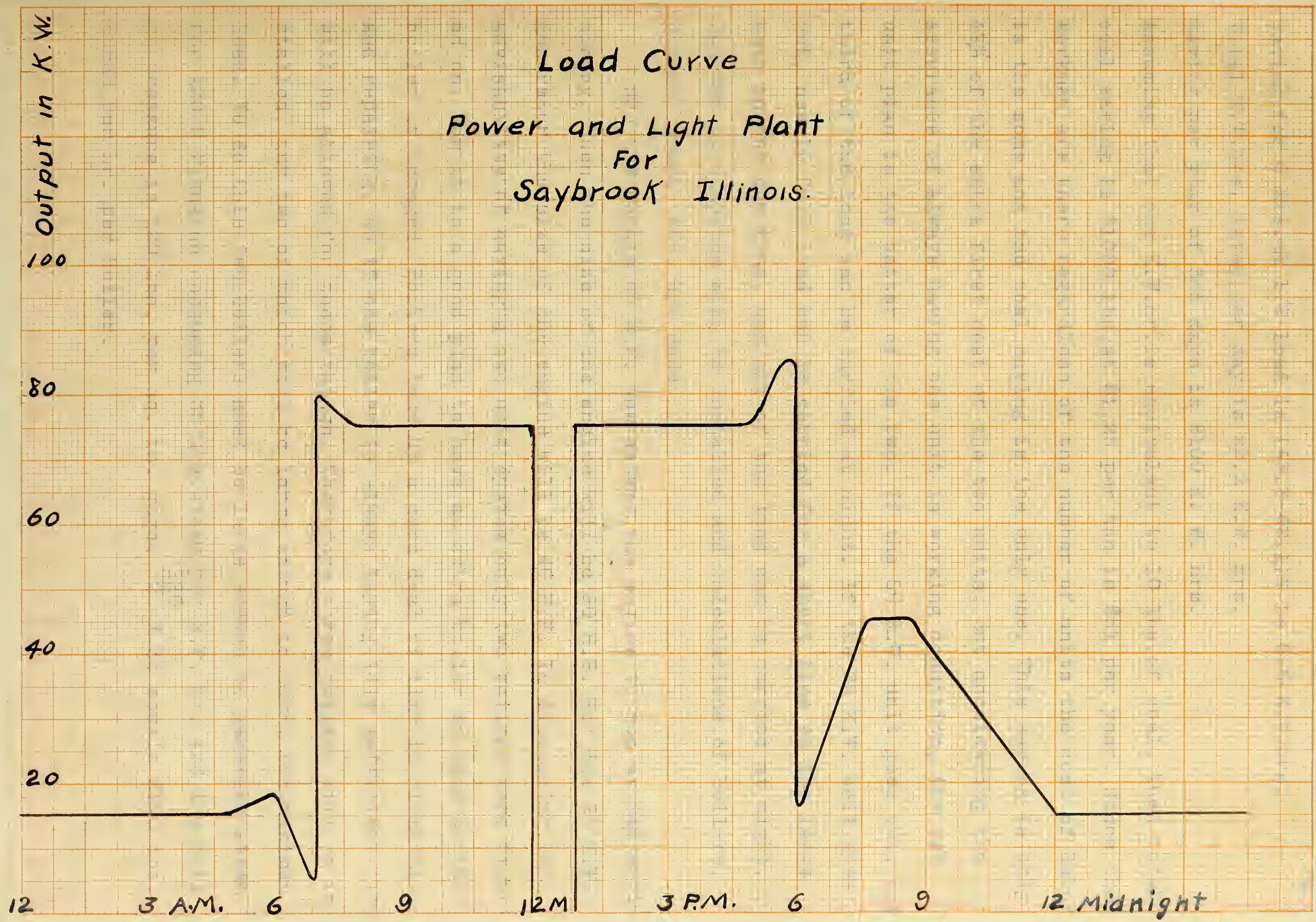
Belted generators

50 K. W. generator	$ 750
25 " "	480
2 exciters	180
Engine settings	196
1 80 H. P. engine	1000
1 40 " "	750
Boilers	1000
Boiler setting	740
Total	$5096

The load curve having been drawn as correctly as possible, the following assumptions are made which go to show the effect of running at full capacity as compared to fractional capacity with low effeciency. Assuming that the life of the machinery is 15 years, and that the two units cost $1000 more than the one unit, then the depreciation on the two units would be 1000/15 which is $67 or 6.7% more than on the one unit. Now the interest on this will be 5% and the insurance 1/2 % or a total Int. Dep. and Ins. of 12.2%. 12.2 % of $1000 is $122 per year. In the case of the 75 K. W. unit running all the time, it will run 6 hrs. at 1/4 load, 10 hrs. at full load, and 6 hrs. at 1/2 load. If the two units are used they will run at nearly full load all the time.

For one unit at 1/4 load the effeciency is 80%
" " " " 1/2 " " " " 87%
" " " " full " " " " 91%
" two " " " " " " " 90%
" " " " 3/4 " " " " 89%

Saving for first 6 hrs. at 1/4 load is (23.5-20.9) 6 is 15.6 K. W.
" " 10 hrs. at full load is nothing.



Load Curve

Power and Light Plant
For
Saybrook Illinois.

Saving for 6 hrs.at 1/2 load is (43.2-42.1)6 is 6.6 K.W.hrs.

Total K.W.hrs. saved per day is 22.2 K.W. hrs.

Saving per year of 365 days is 8100 K. W. hrs.

Assuming that one K.W.hr.is equivalent to 10 lbs.of coal. Then total coal saving is 81000 lbs.at $1.25 per ton is $51 per year. Since the workmen are there regardless of the number of units the cost of labor is the some and the coal saving is the only one. This saving is only 42% of the extra first cost of the two units. But considering the assurance of always having one unit in working condition, the two unit plan is the better of the two. If the 50 K.W. unit goes out, one third of the load can be carried at night. If the 25 K.W. unit goes out, nearly full load can be carried for a short time on the large unit in the day time, and all of the load can be carried at night. The two unit system will be installed and calculations of boilers, piping, pumps, etc. are made.

50 K.W.equals 67 H.P. Now assume the engine to run at 84% efficiency, then the size of the engine will be 80 H.P. For the 25 K.W. generator the size of the engine will be 40 H.P. In discussing the advisability of having a two unit system only two boilers were figured on. Now it is a good plan to have an extra boiler in case another boiler is damaged. Boilers take up a good deal of time in cleaning and repairing, so if one boiler is always laying idle sufficient time will be allowed for these things. Therefore three boilers will be installed, any two of which will be large enough to carry the maximum load. To do this two boilers must be large enough to generate steam for 120 H.P.Engine consuming 35 lbs.steam per H.P. hr. and the boiler pressure is 120 lbs. per sq. in. gage. $\frac{120}{2}$ X 35 equals 2100 lbs. steam per hr. per boiler.

The pump must raise 2100 Lbs. of water per hr. 30 ft. against 125 lbs. pressure.

Pressure of water per sq. in. under 1 ft. load equals .43 lb.

125/.43 equals 290 ft. head.

Total lift equals 290 plus 30 equals 320 ft.

Assuming 2% loss is 40 lbs. Then total amount must be 2140 lbs.

2140/60 equals 35.8 lbs. water per min. for pump to lift.

35.8 times 320 equals 11450 ft. lbs. per min.

11450/33000 equals .43 H. P. pump.

The pump and engine will run at 50% effeciency. Then size of steam end at 50% is .86 H. P., or to be safe, and as they are only made regularly in even sizes a 1 H. P. pump will have to be used. The pump will consume 100 lbs. steam per hr. Then the total steam consumption is 2240 lbs. steam per hr. at 120 lbs. pressure. The boilers give 34.5 lbs. per H. P. hr. from and at 212 degrees.

2240 lbs. at 120 lbs. pressure is 2320 from and at 212 degrees.

2340/34.5 equals 67 H. P. boilers. Therefore 3,65 H. P. boilers will be installed.

In order to have a spare unit for pumping two pumps with double capacity will be used, in order to supply two boilers with one pump. In case of breakdown, this allows the second pump to supply the water. Injectors would be cheaper, but on account of the difficulty in manipulating, and assuming that cheap labor , and therefore inexperienced labor will be used, it is thought best to use the feed pump system. The boiler takes 2320 lbs. per hr. or 39 lbs. per min. Supply for two boilers is 78 lbs. per min. or 1.25 cu.ft. per min.

1.25 cu.ft. is 9.4 gal. per min. Therefore the pump must be able to supply 9.4 gal. of water per min. to the boiler. In case an

open feed water heater is used the pumps must be a little larger in order to maintain a storage tank of water.

The size of the chimney is to be considered now. It should be large enough for two boilers, but in case the load required three boilers, it should be large enough to carry the smoke and gases for three boilers. It is a good plan to build a chimney for three boilers, because a brick chimney has such a long life that it will outlive all the other machinery, and therefore should be designed for the future growth of the plant. Three boilers of 67 H. P. were found to be the correct size, but owing to the fact that full load will not be carried all the time, and that some overload capacity can be allowed for, and that the closest size made is 65 H. P. three 65 H. P. boilers will be used.

3 boilers of 65 H. P. is 195 H. P. total.

1 boiler H. P. equals 33305 B. T. U. per hr.

1 lb. coal equals 12000 B. T. U.

195 H. P. equals 6500000 B. T. U. per hr.

6500000/12000 equals 541.6 lbs. coal per hr.

Assume 70% of heat given by the coal to be taken by water and steam.

541.6/.70 equals 770 lbs. coal per hr. total.

Chimney formulae is A equals $\frac{.06\ W}{\sqrt{H}}$

H equals height of chimney in ft.

W equals total weight of coal consumed per hr.

A equals Area of chimney in sq. ft. effective.

A equals $\frac{.06 \text{ times } 770}{\sqrt{70}}$ equals 5.5 sq. ft.

Allowing 2 in. all around for friction, the actual area would be 7 sq. ft. inside.

In determining the size of the header from the boilers to the engines, not more than 2% loss should be allowed in the pipes.

Assume 4 in. pipe for the header from boiler to engine connections.

P equals Q /9 X 10^6 X D d^5 L equals 46 ft.

Q equals 120 X 35 equals 4200 lbs. per hr.

Equivalent length to make up for valves and bends is 100 ft.

Total length L equals 146 ft.

$$P \text{ equals } \frac{175 \text{ X } 10 \text{ X } 186}{9 \text{ X } 10^6 \text{ X } 1024 \text{ X } .27} \text{ equals 1.56 lbs loss.}$$

From header to engine.

L equals 97 ft. including valves and turns

$$P \text{ equals } \frac{97 \text{ X } 785 \text{ X } 10}{9 \text{ X } 10^6 \text{ X } 525 \text{ X } .27} \text{ equals .62 lbs loss.}$$

Total loss is .62 plus 1.56 equals 2.68 lbs. loss.

2.68 is 1.8% loss which is inside of the limit specified. Therefore 4 in. header is the right size to use.

Specifications and Cost
# of the
Work, Material and Equipment
required for
Saybrook Light and Power Plant.

In the specifications following, any material and equipment which will correspond approximately to the specifications will be accepted, however the material and equipment named is recommended for use in this plant.

Boilers.

The boilers shall be fire tube boilers with a capacity of 65 H. P. They shall be of standard make and have 12 ft. of heating surface per horse-power. They shall have approximately the following dimensions:-

Diameter of boiler 54 inches.
Length of tubes 16 ft.
Number of tubes 3 in. in diameter 60
Length of grates 54 in.
Diameter of dome 30 in.
Height of dome 34 in.
Thickness of shell 5/16 in.
Thickness of main heads 7/16 in.
Width of setting 7 ft. 10 in.
Length of setting 20 ft.

The horrizontal, return tubular, stationary type boiler made by Erie City Iron Works is chosen and cuts of it as shown on plates numbers 7,8 and 9.

Engines.

The engines shall be self oiling of standard make with a steam consumption of 35 lbs. steam per horse power hour. They shall have a capacity of 80 and 40 H. P. respectively. They shall have approximately the following dimentions:-

	80 H. P.	40 H. P.
Cylinder	10 x 12	7 x 10

Wheels diameter	54 in.	48 in.
Wheeels width	10 in.	8 in.
Diameter of steam pipes	3-1/2 in.	2-1/2 in.
Diameter of exhaust pipes	5 in.	4 in.
Floor space	9 ft. 6 in. by 4 ft.9 in.	8 ft. by 4 ft.
Initial Pressure	120 lbs. gage.	120 lbs
R. P. M.	300	325

The Self Oiling Engine made by the Ball Engine Co. of Erie Pa. is chosen and cuts of it are shown on plates numbers 4 and 5.

Pumps.

The pumps shall be of standard make, and be able to raise 9.4 gal. of water per min. 30 ft. and force it into the boiler against 120 lbs. pressure. They shall have approximately the following dimentions:-

Diameter of steam cylinder 3 in.
Diameter of water piston 2-1/2 in.
Length of stroke 3 in.

Gallons pumped per min.	12
Strokes per min.	80
Size of steam pipe	3/8 in.
Size of exhaust pipe	1/2 in.
Size of suction pipe	1-1/8 in.
Size of delivery pipe	3/4 in.
Length	2 ft.
Width	9 in.

The pump chosen is the Worthington Piston Pump for boiler feed and gerneral service used with a pressure not to exceed 150 lbs.

Feed Water heater.

The feed water heater shall be a exhaust steam open type

heater. It shall be of horrizontal type with removable plans for cleaning. It shall have attached to it an oil catcher to seperate the oil from the exhaust steam entering. The heater shall have approximately the following dimentions:-

Length	5 ft.
Width	3 ft.
Height	3-1/2 ft.

The heater chosen is a Hoppes Horizontal Exhaust Steam Open Feed Water heater and cuts are shown on plate 6.

Chimney.

The chimney shall be made of radial brick. It shall be 70 ft. high and have an inside diameter of 7 sq. ft. It shall be 2 brick thick at the bottom and one brick thick at the top. There shall be no ornamentation on it except at or near the top.

Generators.

The generators shall be of belted type alternating current. They shall be able to carry their full load at unity power factor continuously with a rise in tempature not to exceed 40 degrees centigrade on any part, and carry 25% overload for two hours longer at unity power factor with a rise in temperature not to exceed 55 degrees C. on any part. The inherent regulation at full non-inductive load, as measured according to A. I. E. E. standard, shall not exceed 8% with the above conditions. They shall hate approximately the following dimentions:-

	50 K. W.	25 K. W.
Length	55-1/4 in	55-1/4 in.
Width	53-3/4 in.	50-1/2 in.
R. P. M.	1200	1200
Weight	3700 lbs.	3200 lbs.

Height	41 in.	41 in.
Main pulley diameter	16 in.	16 in.
Exciter pulley diameter	5-5/8 in.	5-5/8 in.

The generators chosen are of 50 and 25 K. W. capacity respectively made by the Crocker Wheeler Co. of Ampere N. J. Cuts of the generator are shown on plates numbers 10 and 11.

Switchboard.

The switchboard shall have three slate panels 1-1/4 × 24 × 60 inches, elevated 1 ft. above the floor on legs. The instruments shall be of the Weston type except the wattmeters which shall be Thomson type. Due to a three phase circuit there must be an ammeter in each wire leading from the generator. To be able to tell how much load each generator is carrying wattmeters must be included in their circuits. An ammeter must be placed in the arc light circuit as it is necessary to know at all times what this current is. Recording wattmeters must be placed on the motor circuits. A synchroscope must be installed for the purpose of synchromizing. The oil switches shall be of the Hartman type and the circuit breakers shall be three pole overload type. Double pole switches must be installed in order to equalize the load on the three phases at night. A constant current transformer shall be placed in the arc light circuit- cuts are shown on plates numbers 12,13 and 14.

Building.

The building shall be fire proof and the walls made of brick. There shall be a 2 ft. fire wall all around except at the back of the building. The roof shall be a gravel roof. The floors and the foundations shall be concrete made of bank run gravel and Portland cement. The plan and elevations of the building with dimensions are shown on plates numbers 2 and 3. The piping designs are shown

on these plates.

Cost of building.

75000 brick at $8 per M.	$ 600.00
74 brl. lime at $1	75.00
42 yds. gravel at 60 cts.	25.20
63 brl. cement at $1.25	79.00
50 yds. gravel at 60 cts.	30.00
57 yds. gravel at 60 cts.	34.00
71 brl. cement at $1.25	82.50
22 2 times 6 22 ft. at $25 per M.	12.10
50 2 times 6 18 ft. at 23 per M.	20.70
3000 ft. sheeting at 25 per M.	75.00
30 squares roofing at $4 per square laid	120.00
20 2 x 6 22 ft. at $25 M.	11.00
8 2 x 6 12 ft. at 22 M.	2.20
1100 sq. ft. ceiling at 25 M.	27.50
25 2 x 4 10 ft. at 22 M.	3.90
1200 lath at 6 M.	7.20
80 yds. plastering at 30 cts. per yd.	24.00
8 windows 40 x 42 2 ft. at $4.45	35.00
2 doors 2-6 x 6-6 at $2.40	4.80
2 " 3-6 x 7 at $ 2.50	5.00
2 " 3 x 6-6 at $ 2.50	5.00
200 lbs nails at 5 cts per lb.	10.00
Lumber for scafolding and miscellaneous	25.00
Wages for superintendant of building	50.00
Incidentals not itemized	100.00
Work on building	478.50
Total cost of building	$1942.60

Cost of Line.

160 poles 30 ft. 6 in. top	$ 480.00
40000 ft. No. 6 wire at 15 cts per lb.	675.00
3000 ft. No. 8 wire at 15 cts per lb.	65.00
160 cross arms 48 in. 41 in. 3-1/4 x 4-1/2 in	31.00
640 1-1/2 in. locust wood pins	10.00
160 5/8 inch 10 in. bolts	16.50
620 flat braces 3/16 by 1 inch	24.50
480 3/8 by 4 inch carriage bolts	11.00
20 guys for corner poles	11.90
16 strands twisted wire for arc suspension	7.00
2 15 K. W. transformers	240.00
8 10 " "	700.00
8 4 " "	370.00
1 constant current transformer for 16 arcs	370.00
Creosoting 160 poles, setting & equiping poles	200.00
700 glass Insulators	26.00
Stretching wire	100.00
16 arc lamps and hangings	350.00
Total cost of line.	$3687.90

Cost of Switchboard.

2 circuit Creakers	$ 80.00
6 oil switches	360.00
2 recording wattmeters	130.00
2 D. C. ammeters	32.00
2 D. C. voltmeters	32.00
2 A. C. ammeters	114.00
2 A. C. voltmeters	46.00
3 slate panels	54.00

Synchroscope	$ 50.00
2 wattmeters	120.00
Total cost of switchboard.	$1018.00

Cost of piping.

7 ft. 6 in. pipe	$ 8.15
12 ft. 5 in. pipe	10.50
4 ft. 4 in. pipe	2.40
90 ft. 3/4 in. pipe	5.40
38 ft. 1-1/4 in. pipe	4.56
60 ft. 1 in. pipe	4.80
56 ft. 4 in. pipe	33.60
11 ft. 3-1/2 in. pipe	6.00
12 ft. 2-1/2 in. pipe	3.90
1 2-1/2 in, globe valves	2.70
1 3-1/2 in. globe valves	4.60
3 4 in. angle valves	17.10
2 2-1/2 in. 90 degrees elbows	.72
2 3-1/2 in. 90 degrees elbows	2.00
3 4 by 4 in. Tee connections	1.59
1 2-1/2 by 4 in. Tee connections	.60
1 3-1/2 by 4 in. Tee connections	.60
3 1-1/4 in. elbows	1.05
3 3/4 in. elbows	.50
2 3/8 in. elbows	.30
1 3/8 in. Tee	.15
1 1-1/4 in. Tee	.40
Nipples various sizes	1.50
3 3/8 in. globe valves	1.50

3 1-1/4 in. globe valves	$ 4.80
6 3/4 in. globe valves	5.30
Work on piping	25.00
Total cost of piping	$ 149.62

Cost of Plant Complete.

Building	$ 1942.00
Engines	1750.00
Generators	1230.00
Boilers	1248.00
Engine Settings	196.00
Generator Settings	50.00
Boiler Settings	800.00
Exciters	180.00
Feed water heater	130.00
Piping and fittings	150.00
Pumps	75.00
Switch board and attachments	900.00
Storage tank	40.00
Line	3687.00
Chimney	1750.00
Work on switchboard	25.00
Total cost of plant.	$14153.00

Finances.

Receipts:-

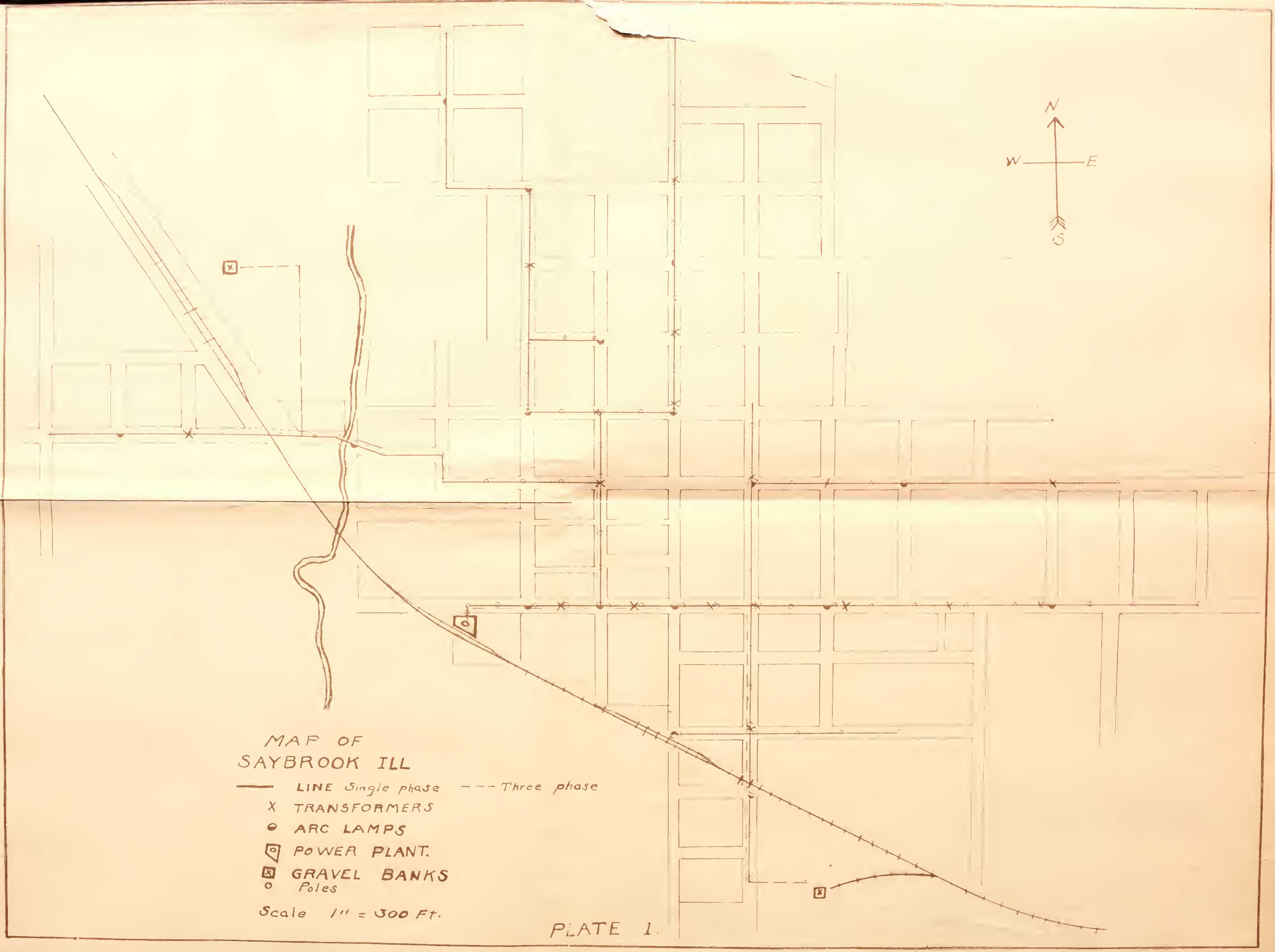
Motor load 750 K. W. hr. per day. 300 days at 3 cts.K. W. hr.	$6750.00
16 arc lights at $80 per year	1280.00

Lighting load 197 K. W. hr. per day 360 days at 15cts. K. W. hr.	$1065.00
Total	$9095.00
Expenditures:-	
Coal at $1.25 per ton	$1080.00
Labor of 2 men at $2 per day 360 days	1440.00
Labor of 1 man as manager	1000.00
5% Int Dep. and Ins on building	94.00
14% Int. Dep. and Ins. on machinery	1720.00
Coal handling at 6 cts. per ton	51.00
Oil and waste	150.00
Total	$5535.00

Net receipts are $3,560 per year.

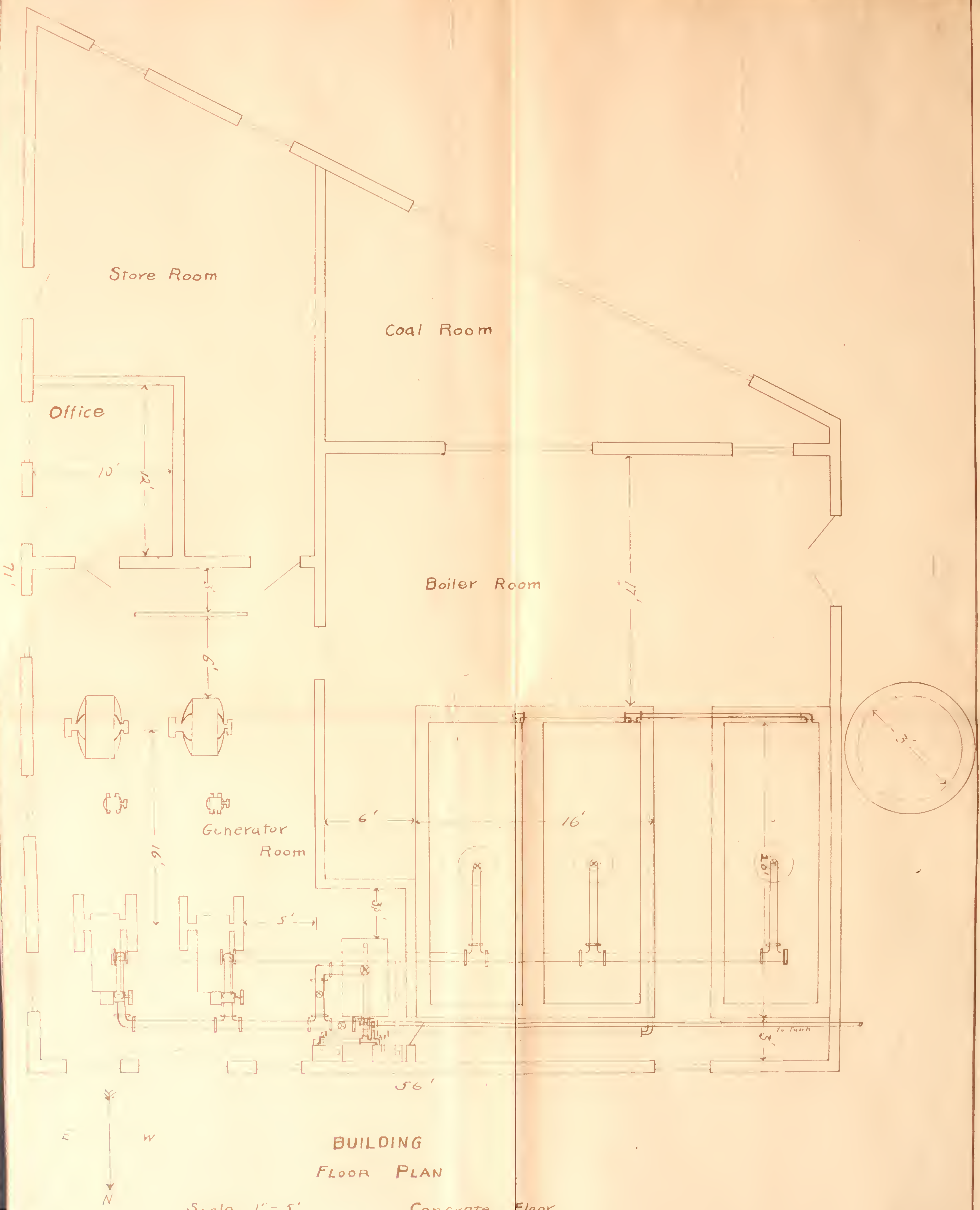
$3560 is 25% of investment and 8.4 % of three times the capital stock.

Therefore this plant would be a profitable undertaking for, central stations which pay six per cent dividends on three times the capital stock invested are considered a financial success.



MAP OF
SAYBROOK ILL

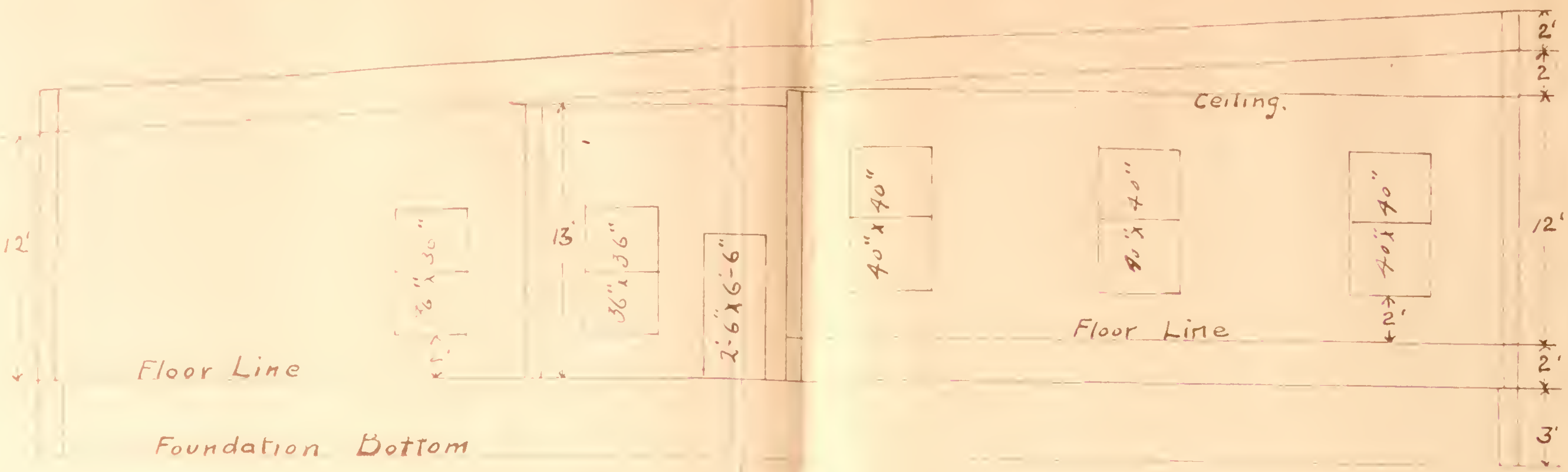
PLATE 1.



BUILDING
FLOOR PLAN

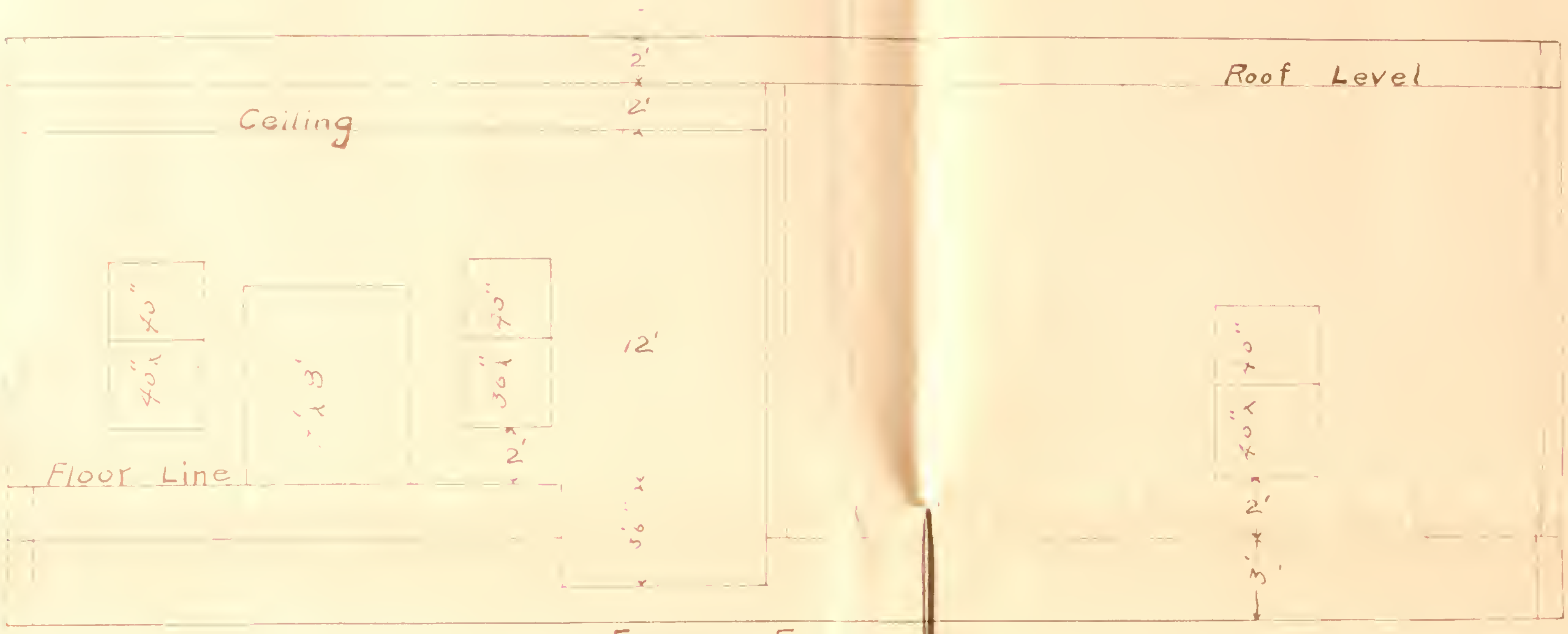
Scale 1" = 5'   Concrete Floor

Plate 2



EAST SIDE ELEVATION.

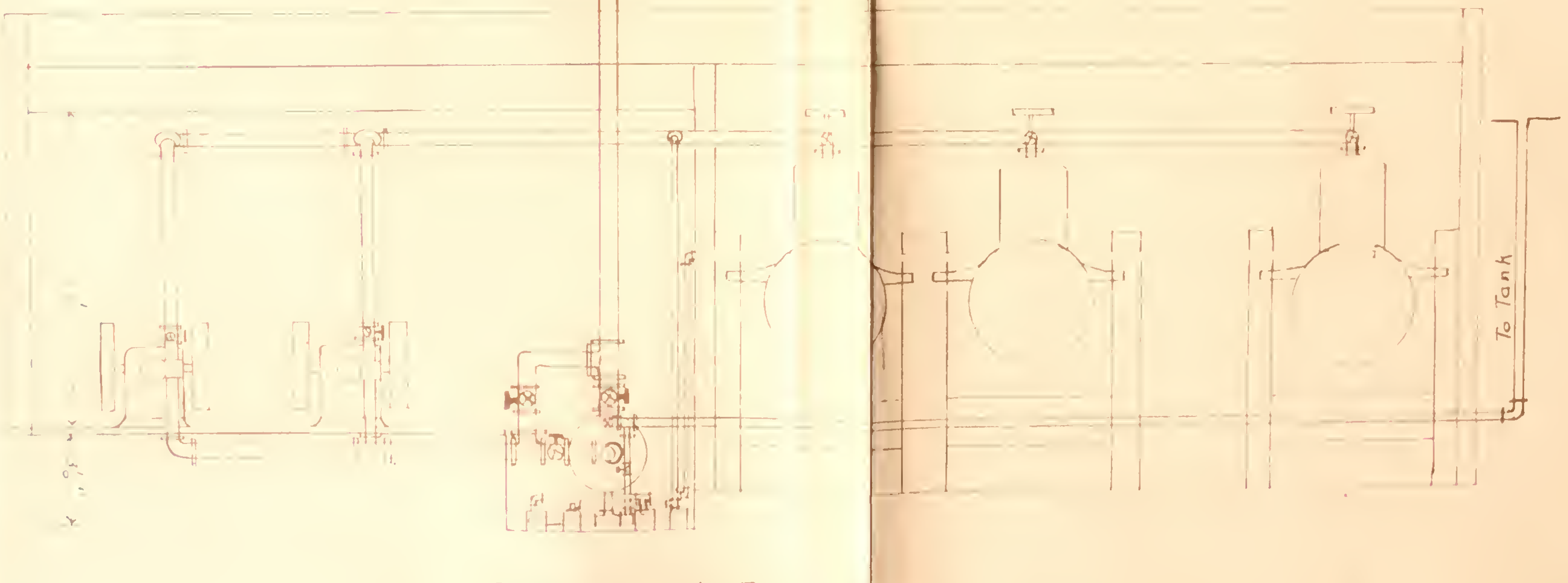
Scale 1"=6'



FRONT ELEVATION.

Scale 1"=5'

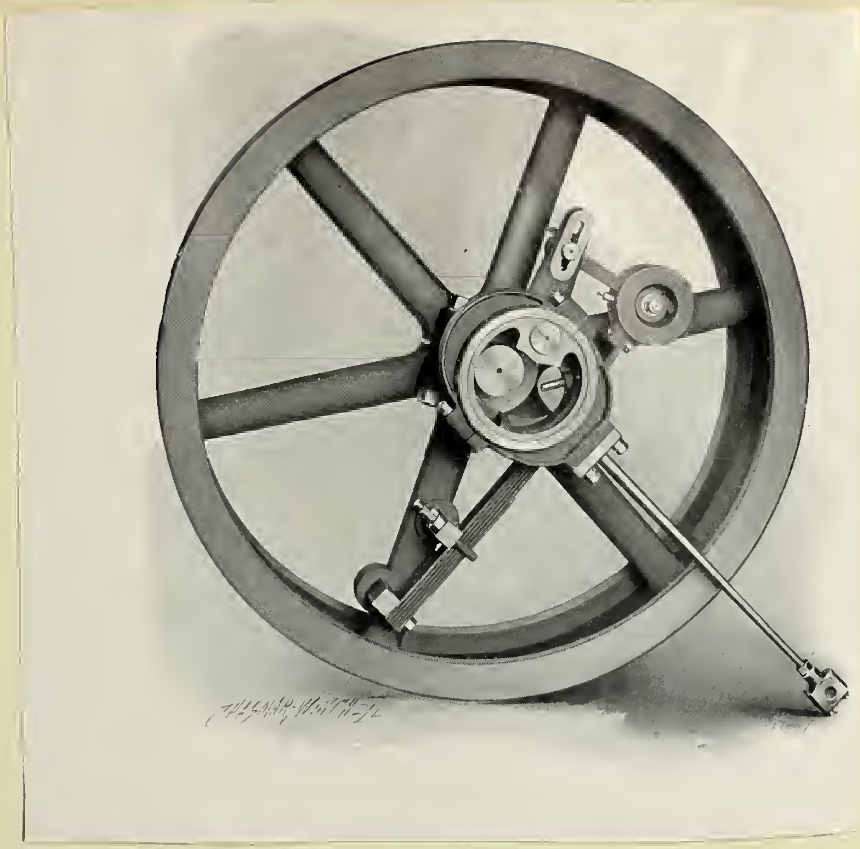
8" Brick Walls.

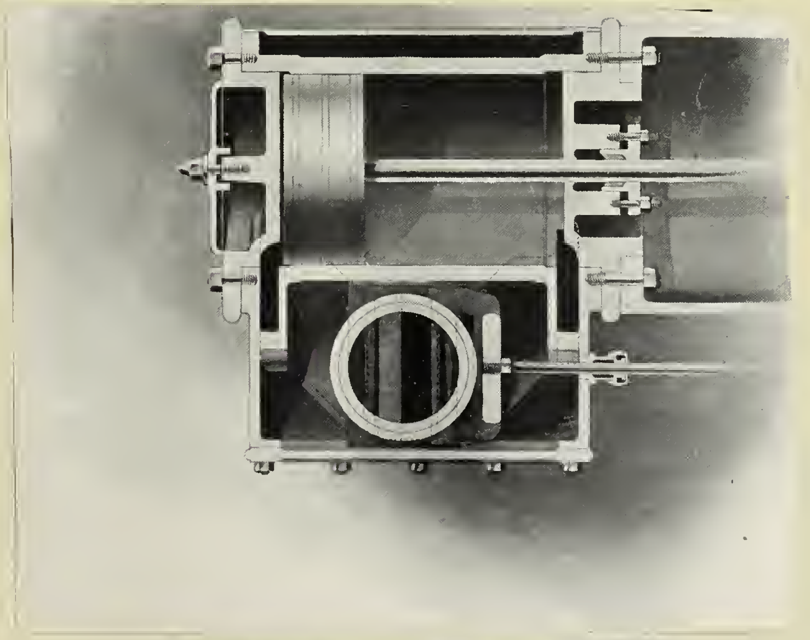


SECTION 12' FROM FRONT

Scale 1" 5'

Plate 3





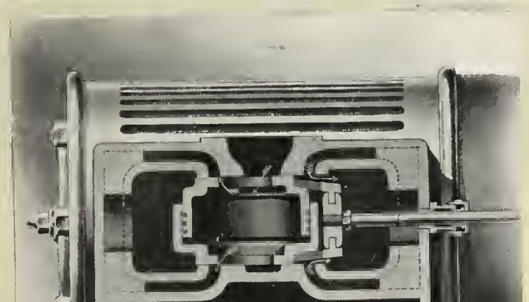
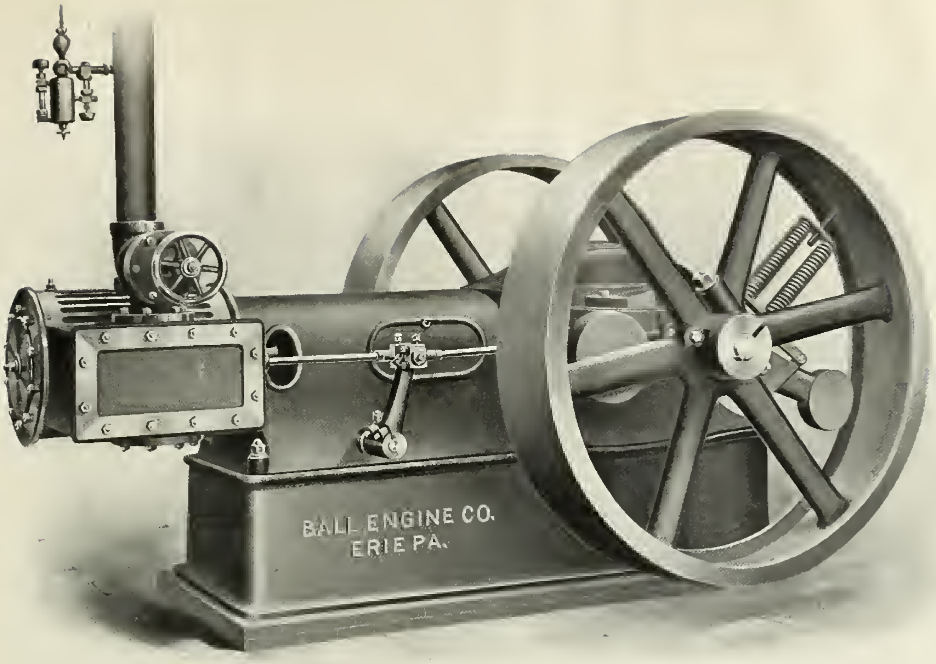
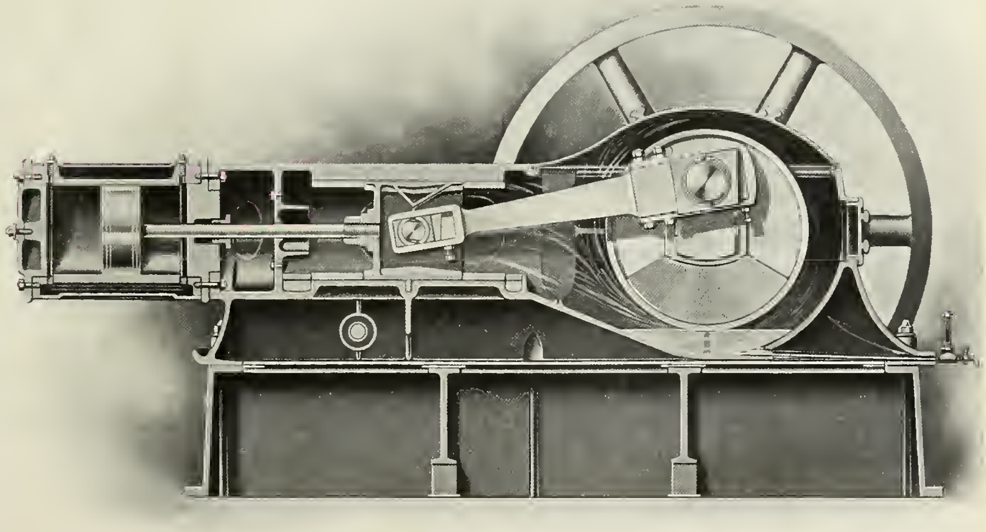


Plate 4

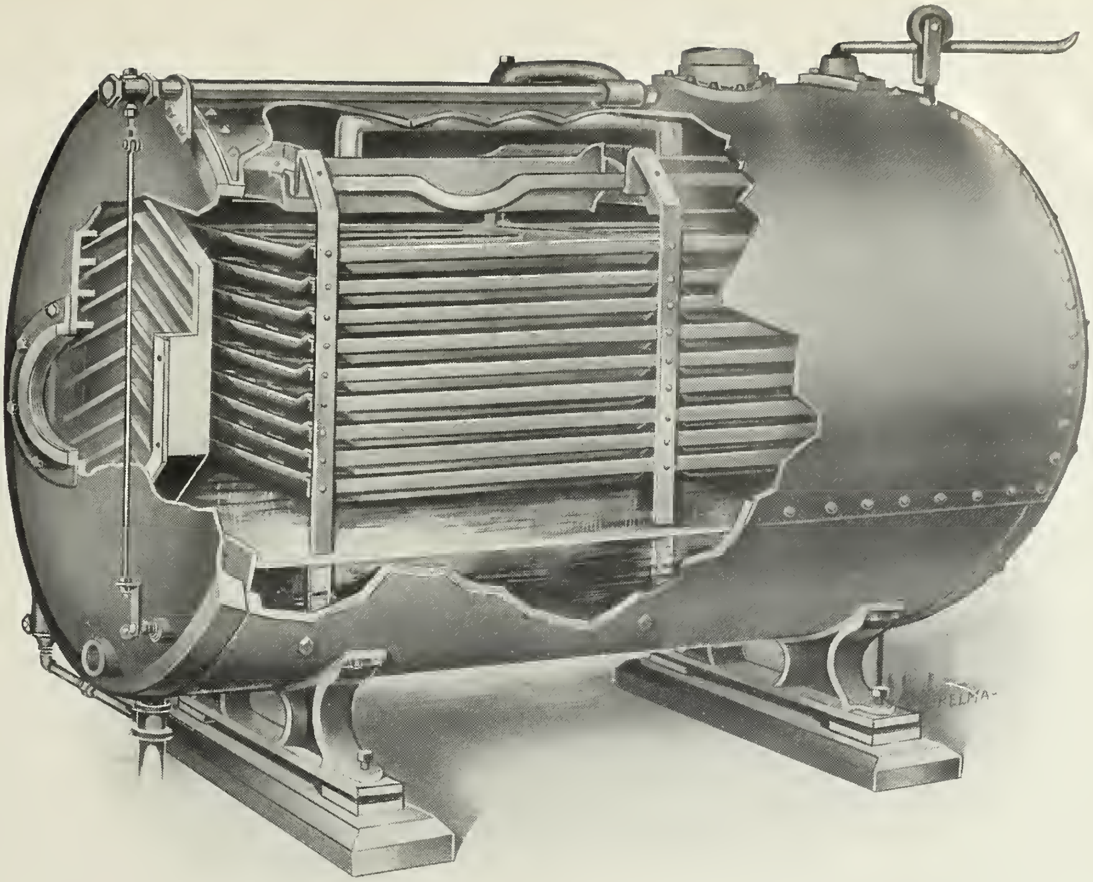


Single Cylinder Engine



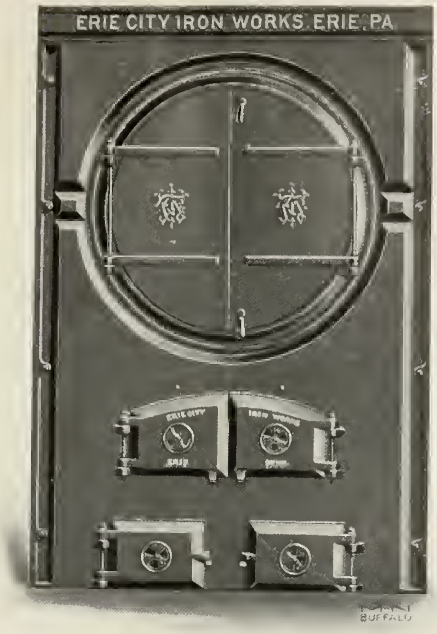
Longitudinal Section

Plate 5



Class "R"—Hoppes Feed-Water Heater and Purifier.

Plate 6



Full Front — Fig. "C"
This is furnished with our regular Full Front fixtures.

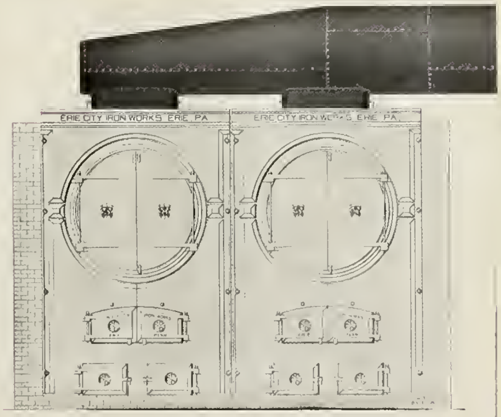
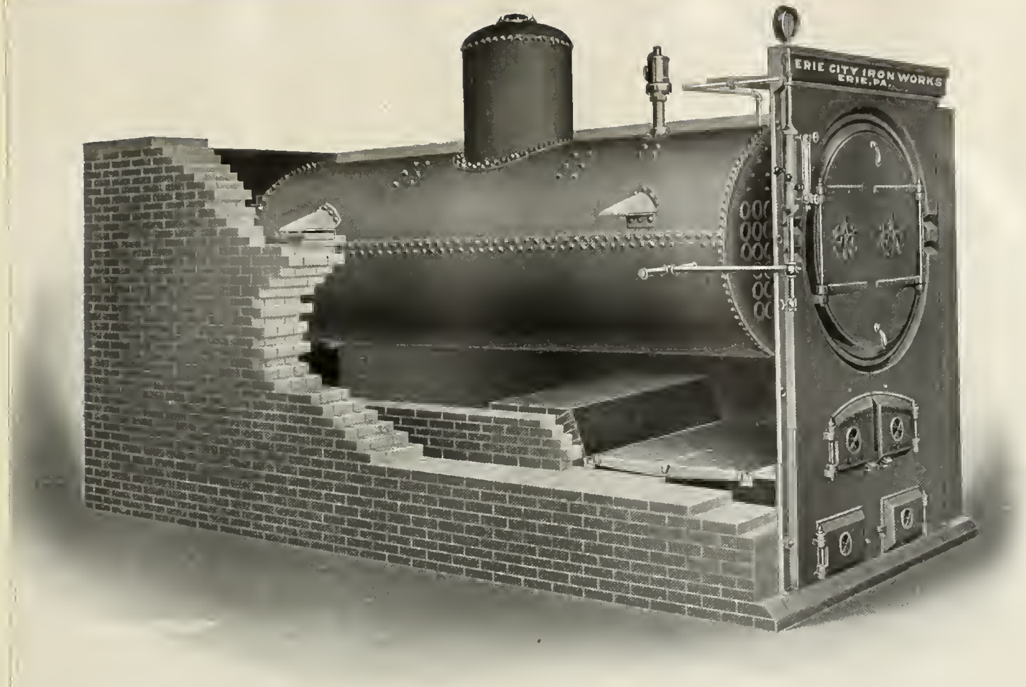
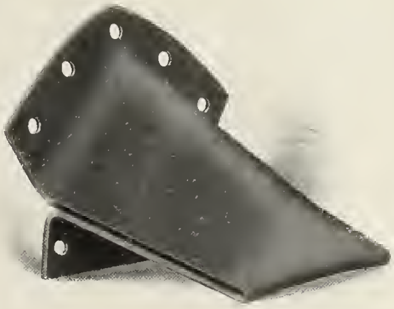


Fig. "D," for Two or More Boilers



Horizontal Return Tubular Stationary Boiler

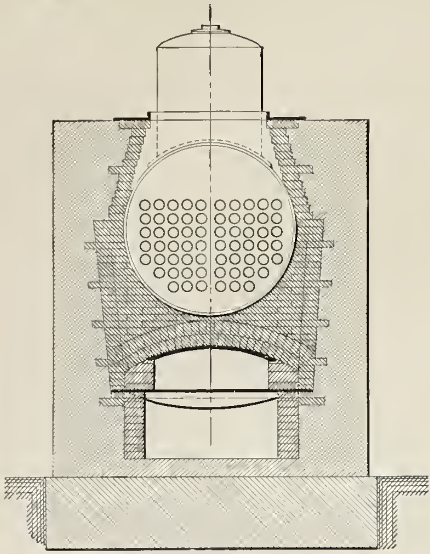
Regular Plain Grate
This Grate is sent unless otherwise specified



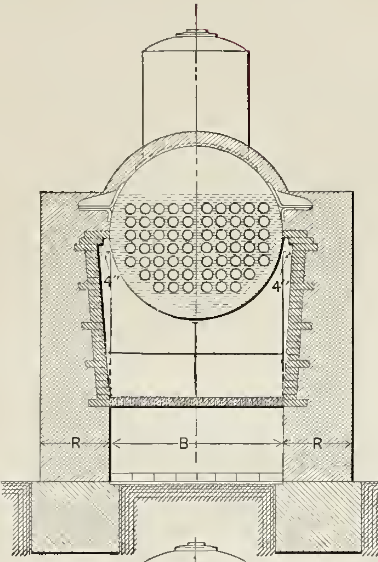
Side Wall Bracket

Plate 8

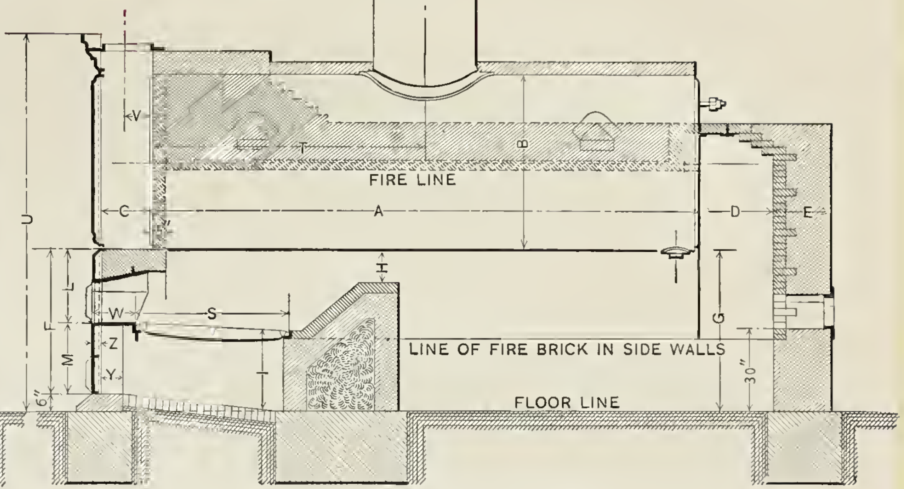
ERIE CITY IRON WORKS



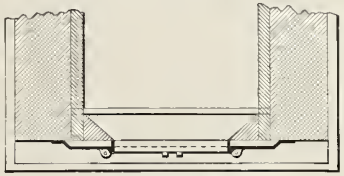
Section Through Arch



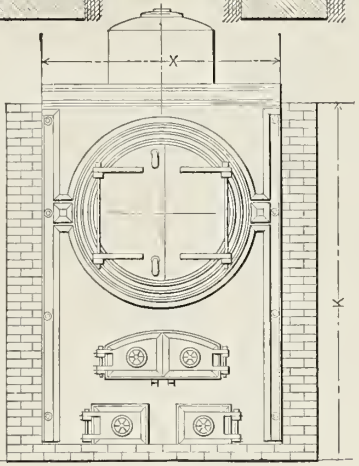
Section Through Furnace



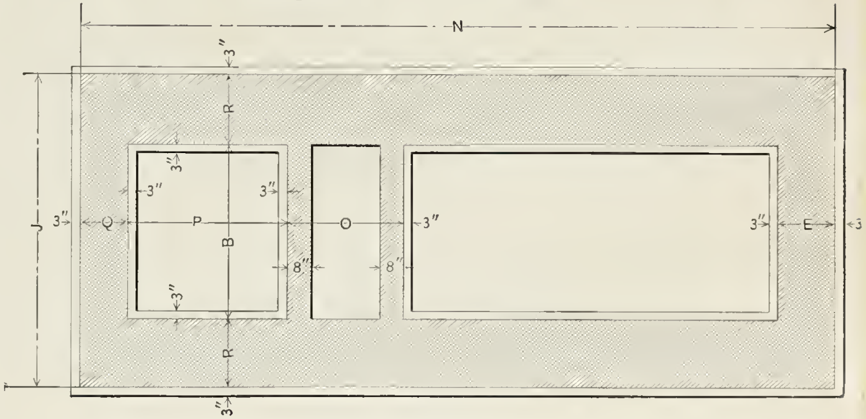
Longitudinal Sectional Elevation



Sectional Plan
Through Fire-Doors



Front Elevation

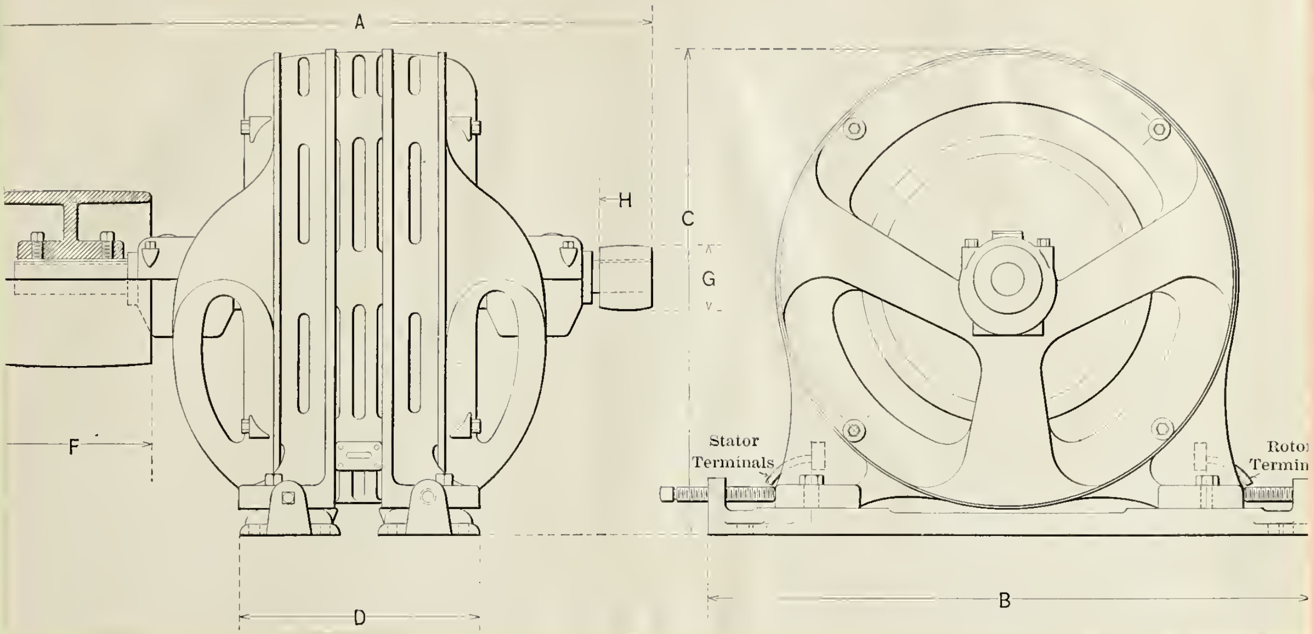


Ground Plan

SETTING FOR STATIONARY
FULL FRONT BOILERS

In setting Stationary Boilers, the side walls should be so built that the longitudinal seams of the shell will be protected from the fire. Pressed Steel Wall Brackets furnished on the larger sizes.

Plate 9



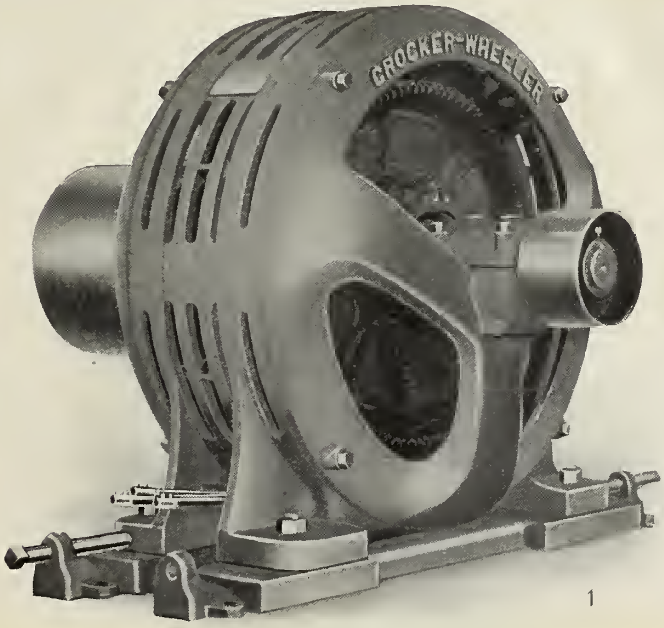


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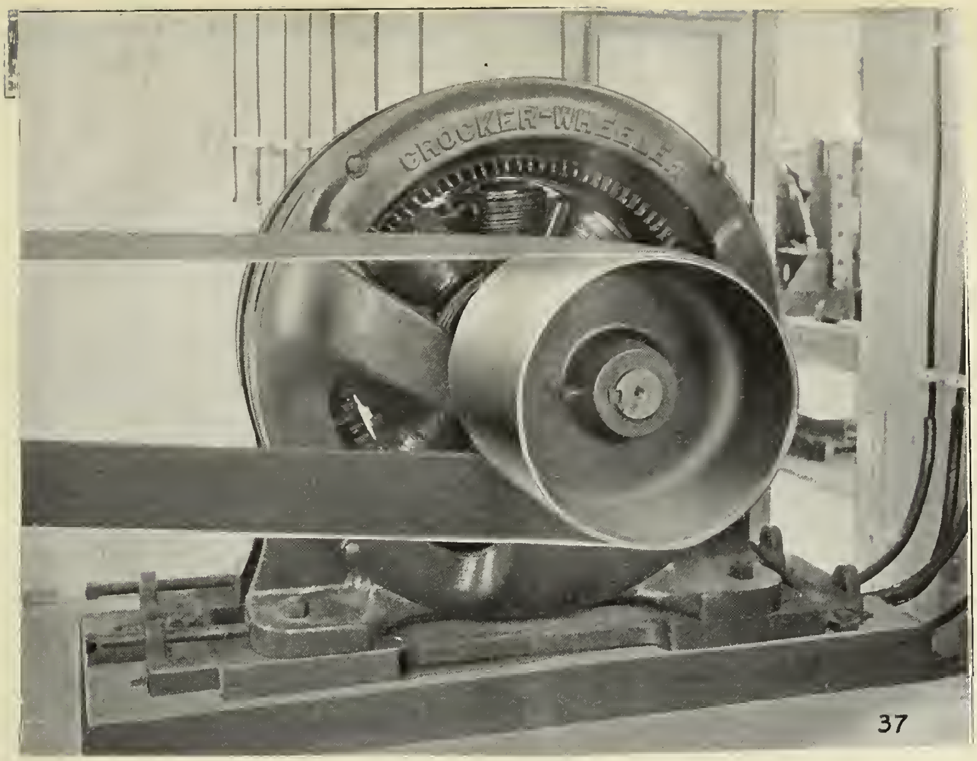
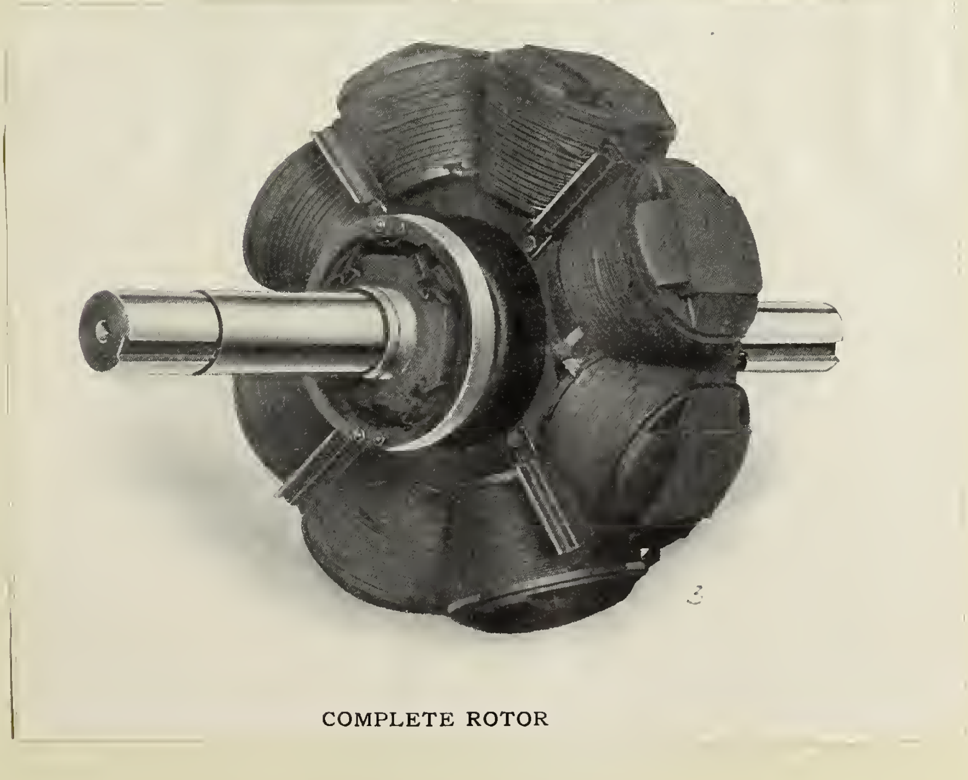
Plate 10





COMPLETE ROTOR

Plate 11

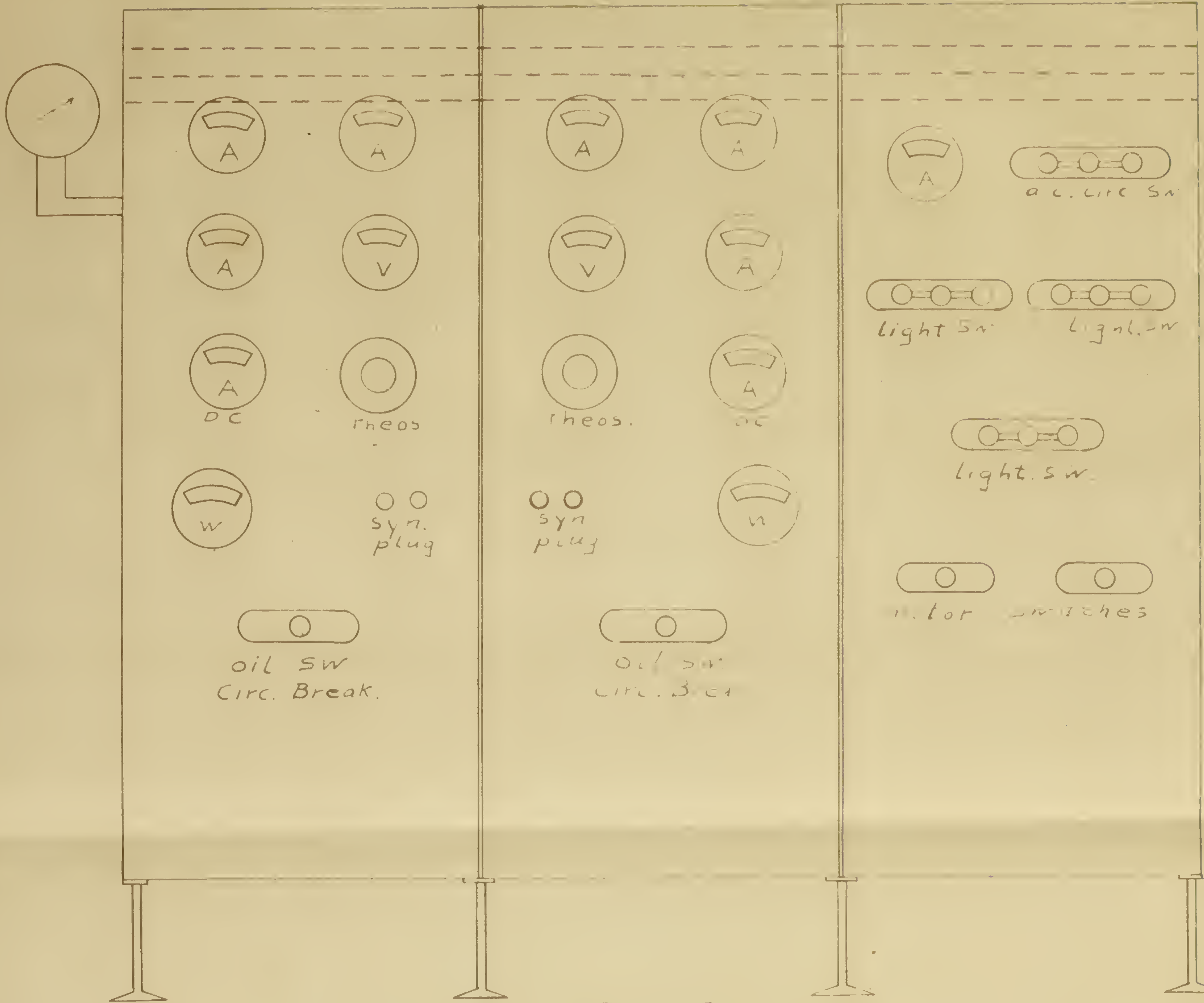

A
A
A
A
V
A
DC
rheos
W
syn.
plug
oil SW
Circ. Break.
A
A
V
A
rheos.
DC
syn
plug
W
Oil Sw
Circ. Break
A
a.c. Circ Sw
light Sw
Light Sw
light. Sw.
Motor switches

PLATE 12

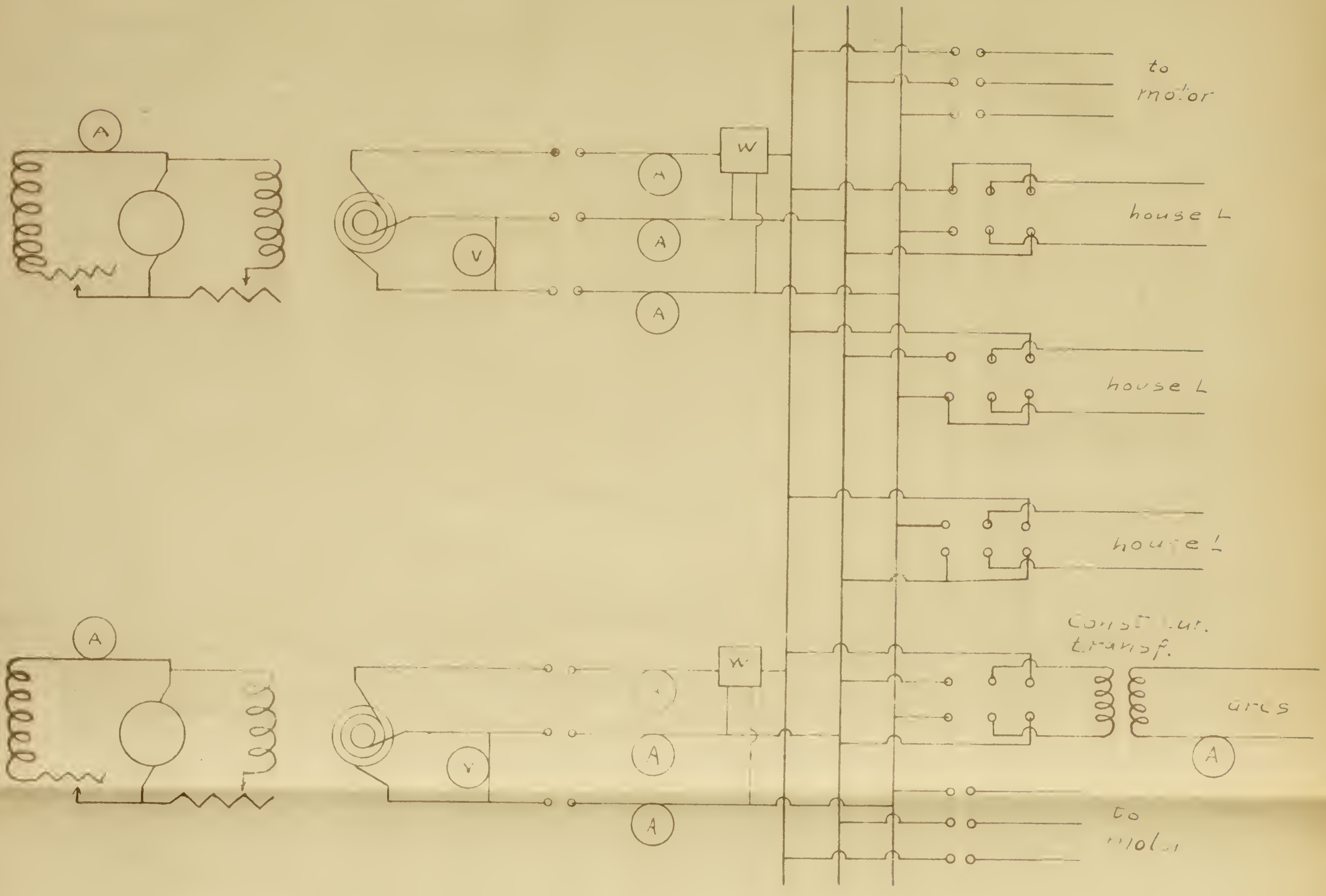
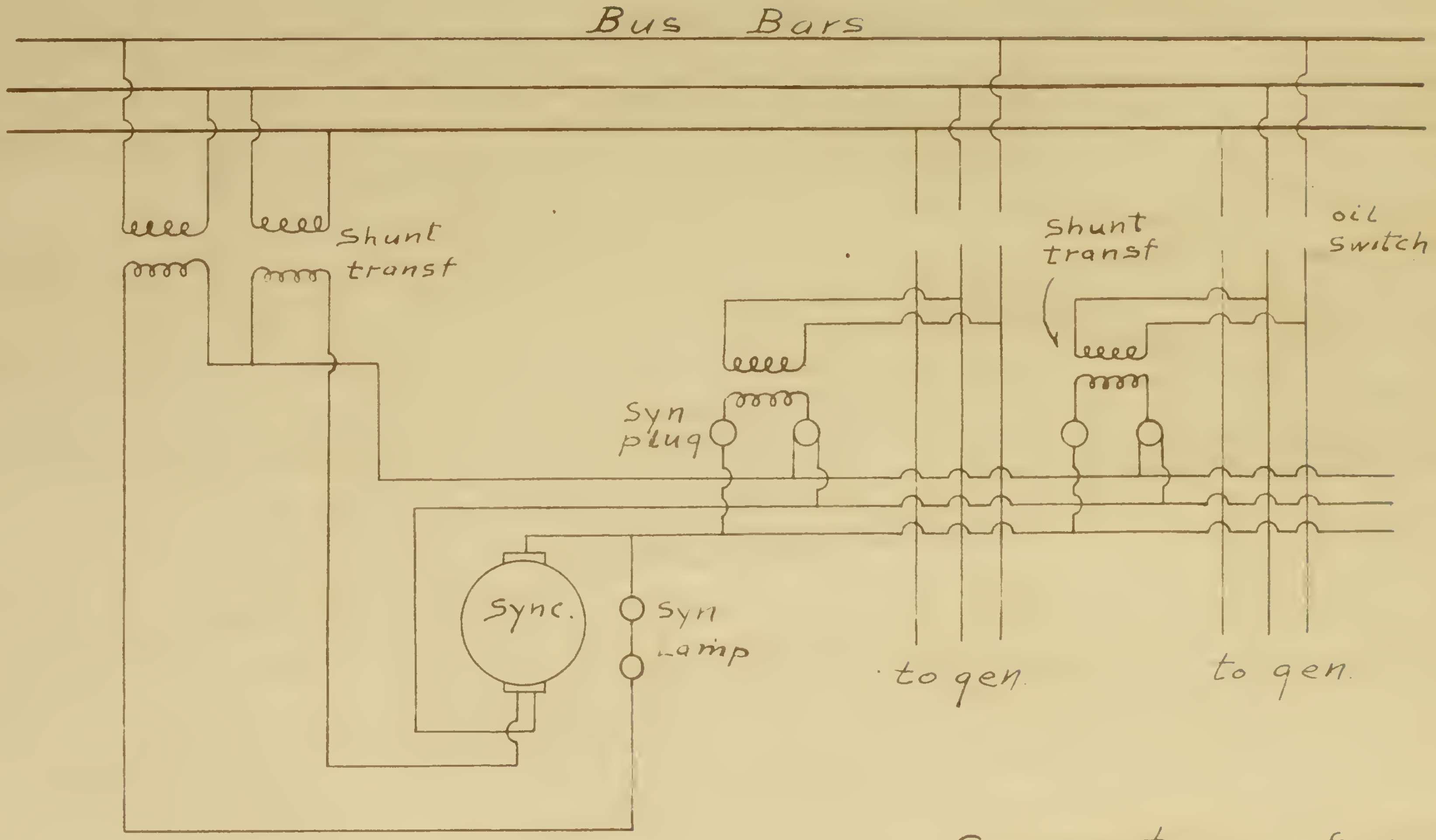

to motor
house L
house L
house L
const. cur. transf.
arcs
to motor
W
W
A
V

PLATE 13



Connections for Synchronizing

PLATE 14

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